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BALLOON SYSTEMS AND LAUNCH SUPPORT.(U)

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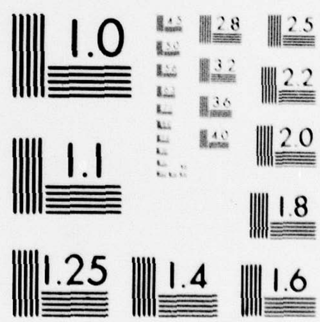
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AFGL-TR-79-0175

BALLOON SYSTEMS AND LAUNCH SUPPORT

Stewart P. Bean
John R. Ground

Physical Science Laboratory
New Mexico State University
Box 3-PSL
Las Cruces, New Mexico 88003

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Final Report
1 October 1976 - 31 January 1979

Approved for public release; distribution unlimited

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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Air Sampling Balloons

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work performed under this contract consisted of; conducting balloon flight operations from selected sites; integrating GFE instrumentation and flight safety equipment into balloon borne payloads; providing engineering support for payload integration and integrity; fabricating, calibrating and repairing command control/telemetry equipment; analyzing data; and reporting flight results.

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SUMMARY

The objective of this work effort was to collect stratospheric samples by integrating electrical and mechanical hardware into a balloon borne system. Then, launch the system into the atmosphere, collect the desired sample, recover the system, analyze the results and prepare summary reports.

1.0 INTRODUCTION

1.1 On October 1, 1976 PSL, under Air Force Contract F19628-77-C-0031 assumed responsibility for a large portion of the high altitude balloon sampling work conducted by AFGL. This effort involved parts of the entire Atmospheric Measurement Prgram; however, the work efforts were directed primarily toward Project Ash Can.

1.2 The first quarter year efforts were directed toward training as PSL became familiar with the equipment and operational requirements.

1.3 The second quarter year PSL performed all the operational functions under the guidance of the Air Force controllers. By midyear of 1977 PSL had assumed full operational control of the Program. From July 77 to January 79 PSL has had full responsibility and control of the program.

2.0 SCOPE

2.1 The Physical Science Laboratory, New Mexico State University, (PSL/NMSU), supplied the necessary personnel, services, specified materials and engineering assistance for seventy-one (71) balloon research flights conducted at Holloman AFB, NM; Albrook AAF, CZ; and Eielson AFB, AK. In support of this effort PSL:

2.1.1 Operated and maintained (GFE) telemetry and command stations, performed payload preparation and integration, and acquired real-time and recorded data.

2.1.2 Interfaced (GFE) flight safety and scientific tracking devices, parachute recovery systems, and command/control systems into the balloon flight systems. Provided for the design, fabrication, testing, and installation of subsystems necessary to insure proper operation of these balloon flight systems.

2.1.3 Coordinated balloon flight instrumentation requirements for each operation. Maintained and calibrated scientific and command/control equipment.

Provided technical interface between the AFGL contractor and government operational facilities. Completed flight documentation and facility use agreements. Acted as a technical representative of AFGL when coordinating with scientists and engineers concerned with scientific experiments and data acquisition.

3.0 TECHNICAL PROGRESS

3.1 During the contract period PSL conducted 71 flights and provided technical assistance for 2 flights in support of the Atmospheric Measurements Program. Of the 71 flights, 14 were conducted from Eielson AFB, AK and 10 were conducted from Albrook AAF, CZ. The remaining 47 were conducted at Holloman, AFB, NM. To accomplish these flights PSL calibrated equipment, provided technical interface, assembled payloads, rigged parachutes, conducted flight operations, directed aerial catch recovery missions, monitored ground recovery activities, provided coordination between participating agencies, collected real-time data, made data reductions, packed and shipped equipment, set up remote operational sites, performed site coordination and completed flight documentation and reports.

3.1.1 The period October to December 1976 was a training phase for PSL as we assumed responsibility for the Ash Can Balloon Flight Program. During this period experience was gained in all facets of the program in a hands-on environment. The equipment in use at this time was an early vintage command control data system designated as SCADS-1A.

3.1.2 During this initial phase, because of the condition of the SCADS-1A equipment and our lack of knowledge of these equipment items, the failure rate was high; however, as experience and knowledge were acquired, a program was instituted to repair and recondition all of the SCADS-1A components. As this reconditioning work progressed, knowledge was gained in the intricate functioning of the SCADS-1A as well as the operational areas and the success rate began to improve. By midyear CY1977 there was a definite upswing and during the last half of CY1977 there were seven successful flights, two flights which collected two good and one unusable samples, and one non-success due to aerial retrieval failure. In CY1978 complete samples were collected on 24 flights, a partial sample collected on the metal bellows flight and insufficient sample collected on one flight wherein the balloon sink rate was too rapid. The flights flown and the analyses of failure modes are discussed in paragraphs 3.2 and 3.3.

3.2 The flights flown during the contract period were:

FLIGHT NO.	DATE	ALT (Kft)	BLN SIZE (x $10^6 ft^3$)	TYPE SAMPLER AND EXPERIMENT	REMARKS
H76-58/H-96X	1 Nov 76	120	4.85	Single Air Ejector (HCl and O_3)	Balloon Failed at Launch
H76-59/H-97X	2 Nov 76	105	2.01	Single Air Ejector (HCl and O_3)	Good Sample Aerial Recovery
H76-60/H-98X	3 Nov 76	120	4.85	Single Air Ejector (HCl and O_3)	Ballon Failed at Launch
H76-61/H-99	4 Nov 76	80	0.516	Dual Direct Flow and a Single C-14 Samplers (Radio Nuclides, HCl and C-14)	Good Sample
H76-62/H-100	6 Nov 76	70	0.274	Dual Direct Flow and a C-14 Samplers (Radio Nuclides, HCl and C-14)	No Sample Miswired Cable
H76-63/H-101	8 Nov 76	90	0.859	Four Direct Flow, and C-14 Samplers (Radio Nuclides, HCl, O_3 and C-14)	DFS Samples Contaminated by Impact Damage C-14 Good
H76-65/H-102	15 Nov 76	4.5	0.028	RFI Test of SCADS-2 System	Success
H76-66/H-103	18 Nov 76	90	0.859	Four Direct Flow Samplers (Radio Nuclides and HCl)	Good Sample SCADS-2 Unit Destroyed by High Voltage Line
H76-67/H-104	22 Nov 76	70	0.274	Dual Direct Flow and a C-14 Samplers (Radio Nuclides, and HCl)	No Samples Miswired Cable
H76-68/H105X	3 Dec 76	120	4.85	Single Air Ejector (HCl and O_3)	Good Sample

H77-01/H-106X	11 Jan 77	105	2.01	Single Air Ejector (HCl and O_3)	Good Sample
H77-02/H-107X	13 Jan 77	80	0.516	Dual Direct Flow (Radio Nuclide and HCl)	Good Sample
H77-03/H-108X	17 Jan 77	90	0.859	Triple Direct Flow (Radio Nuclides and HCl)	Launch Vehicle Failed, No Sample
H77-04/H-109X	19 Jan 77	70	0.355	Dual Direct Flow (Radio Nuclides and NCl)	No Sample, Air Serve Valve Failed
H77-05/H-110X	24 Jan 77	120	4.85	Single Air Ejector (HCl and O_3)	No Sample, Balloon Burst 35K
H77-07/H-111X	28 Jan 77	90	0.803	Triple Direct Flow (Radio Nuclides and HCl)	Good Sample
H77-15/P-149	23 Mar 77	70	0.274	Dual Direct Flow and C-14 (Radio Nuclides and HCl)	No Sample, C-130 Winch Failed Payload Destroyed
H77-17/P-150	24 Mar 77	80	0.516	Dual Direct Flow and C-14 (Radio Nuclides and HCl)	Good Sample Aerial Recovery
H77-18/P-151	27 Mar 77	105	2.01	Single Air Ejector (Five Whole Air Samplers and Condensation Nuclei Counter (HCl, Whole Air and O_3)	Good Sample Ground Recovery
H77-19/P-152	29 Mar 77	90	0.859	Dual Direct Flow (Radio Nuclides and HCl)	No Sample, Timer Malfunction
H77-20	30 Mar 77	98	2.01	Grab Sampler, Whole Air Sampler	Good Sample
H77-21/P-153	31 Mar 77	120	4.89	Single Air Ejector Five Grab Sampler Condensation Nuclei Counter (HCl, O_3 and Whole Air)	Aerial Recovery AE Contaminated Grab Sample Good
H77-22/P-154	2 Apr 77	70	0.274	Dual DFS and C-14 (Radio-active Nuclides and HCl)	DOE DFS Failed, Bad Connector. NCAR DFS and C-14 Good

H77-25/H-112	18 Apr 77	70	0.355	Dual DFS AND C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-30/H-113	6 May 77	80	0.516	Dual DFS and C-14 (Radio-active Nuclides and HCl)	Good Sample Aerial Recovery
H77-31/H-114X	9 May 77	105	2.01	Single Air Ejector (HCl)	Good Sample Payload Damage
H77-32/H-115	16 May 77	90	0.859	Triple DFS and C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-33/H-116X	17 May 77	120	4.89	Single Air Ejector (HCl)	Good Flight
H77-37	15 Jun 77	97	2.01	(Aurora Measurements)	Good Flight
H77-38/A-136	20 Jun 77	70	0.274	Dual DFS and C-14 (Radio-active Nuclides and HCl)	Good Sample Balloon Sank Aerial Recovery
H77-39/A-137	21 Jun 77	80	0.516	Dual DFS and C-14 (Radio-active Nuclides and HCl)	Sample Contaminated Aerial Recovery Failure
H77-40/A-138X	23 Jun 77	120	4.89	Single Air Ejector (HCl)	Good Sample
H77-42/A-139	24 Jun 77	90	0.859	Dual DFS and C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-43/A-140X	27 Jun 77	105	2.01	Single Air Ejector (HCl)	Good Sample Aerial Recovery Failure
H77-44/A-141	29 Jun 77	80	0.516	Dual DFS and C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-46/H-117	19 Aug 77	70	0.355	Triple DFS + C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-47/H-118X	22 Aug 77	94	1.11	Metal Bellows + Dual C-14 (Whole Air Sample, Freons, and CO_2	Good Bellows and One C-14 Other Failed Cap Not Removed

H77-49/H-199	26 Aug 77	80	0.628	Triple DFS + C-14 (Radio-active Nuclides and HCl)	Good Sample
H77-51/H-120	29 Aug 77	90	1.11	Triple DFS + C-14 (Radio-active Nuclides and HCl)	DOE DFS Sample Contaminated Impact Damage NCAR Good C-14 Good
H77-52/H-121X	1 Sep 77	105	1.84	Single Air Ejector	Good Sample
H77-53/H-122X	7 Sep 77	120	4.89	Single Air Ejector (HCl)	Good Sample
H77-60/H-123	12 Oct 77	70	0.355	Dual DFS + C-14 Radio-active Nuclides	Aerial Recovery Failed, System Destroyed
H77-62/H-124	14 Oct 77	80	0.516	Dual DFS + C-14 Radio-active Nuclides	Good Sample
H77-64/H-125	18 Oct 77	90	0.859	Dual DFS + C-14 Radio-active Nuclides	Good Sample
H77-65/H-126	20 Oct 77	70	0.274	Dual DFS + C-14 Radio-active Nuclides	Good Sample
H78-04/H-127X	15 Feb 78	95	1.11	Metal Bellows Whole Air Sample	Partial Sample
H78-06/P-155	6 Mar 78	80	0.516	DFS + C-14 Radio-active Nuclides	Good Sample
H78-07/P-156	7 Mar 78	90	0.859	DFS + C-14 Radio-active Nuclides	Good Sample
H78-08/P-157	9 Mar 78	70	0.274	DFS + C-14 Radio-active Nuclides	Good Sample
H78-12/H-128	12 Apr 78	70	0.274	DFS + C-14 Radio-active Nuclides	Good Sample
H78-13/H-129	13 Apr 78	80	0.516	Dual DFS + C-14 Radio-active Nuclides	Good Sample
H78-14/H-130	15 Apr 78	90	0.859	Dual DFS + C-14 Radio-active Nuclides	Good Sample

H78-17/H-131X	4 May 78	105	1.84	HV3K Radio-active Nuclides	Good Sample
H78-19/H-132X	12 May 78	120	4.89	Cassette Sampler Stratospheric Constituents	Good Sample
H78-21/A-142	29 May 78	70	0.274	DFS + C-14 Radio-active Nuclides	Good Sample
H78-22/A-143	30 May 78	80	0.516	Dual DFS + C-14 Radio Nuclides	Good Sample
H78-23	2 Jun 78	105	2.90	Cryogenic Sampler Whole Air Sample	Good Sample
H78-24/A-144	3 Jun 78	105	1.84	Air Ejector + C-14 Radio-active Nuclides	Good Sample
H78-25/A-145	4 Jun 78	135	10.6	HV3K Radio-active Nuclides	Good Sample
H78-26	7 Jun 78	70	0.355	Cryogenic Sampler Whole Air Sample	Good Sample
H78-29/H-133	18 Jul 78	90	0.859	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Good Sample
H78-30/H-134X	20 Jul 78	135	11.62	HV3K, Radio-active Nuclides	Good Sample
H78-31/H-135	22 Jul 78	80	0.628	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Good Sample
H78-32/H-136	25 Jul 78	70	0.355	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Good Sample
H78-33/H-137X	28 Jul 78	120	4.89	Cassette Sampler Stratospheric Constituents	Good Sample
H78-41/A-146X	11 Sep 78	135	10.6	HV3K, Radio-active Nuclides	Good Sample

H78-53/H-138X	5 Oct 78	70	0.804	Chlorine Sampler Total Chlorine Measurements	Good Sample
H78-57/H-139X	17 Oct 78	120	4.89	Cassette Sampler Stratospheric Constituents	Good Sample
H78-60/H-140	17 Nov 78	70	0.274	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Good Sample
H78-61/H-141	18 Nov 78	90	0.859	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Sinking Balloon Failed to Col-lect Sufficient Sample
H78-62/H-142	28 Nov 78	80	0.516	Dual DFS + C-14, Radio-active Nuclides + Stratospheric Constituents	Good Sample

3.3 The flights that failed to collect a valid sample are:

FLIGHT NO.	DATE	REASON FOR FAILURE	MODE	SAMPLE LOST
H76-58/H-96X	1 Nov 76	Balloon Failed at Launch	a	Air Ejector
H76-60/H-98X	3 Nov 76	Balloon Failed at Launch	d	Air Ejector
H76-62/H-100	6 Nov 76	Cable Miswired	b	Dual DFS + C-14
H76-63/H-101	8 Nov 76	Impact Contamination	c	Four DFS
H76-67/H-104	22 Nov 76	Cable Miswired	b	Dual DFS + C-14
H77-03/H-108X	17 Jan 77	Launch Vehicle Failure, Brakes Locked	d	Three DFS
H77-04/H-109X	19 Jan 77	Air Serve Valve Failure	f	Two DFS
H77-05/H-110X	24 Jan 77	Balloon Burst	a	Air Ejector
H77-15/P-149	23 Mar 77	Aerial Retrieval, Winch Failure	e	Two DFS + C-14
H77-19/P-152	29 Mar 77	Timer Malfunction	f	Two DFS
H77-21/P-153	31 Mar 77	Aerial Retrieval Failure	e	Air Ejector
H77-22/P-154	2 Apr 77	Connector Failure	f	One DFS
H77-39/A-137	21 Jun 77	Aerial Retrieval Failure	e	Two DFS + C-14
H77-47/H-118X	22 Aug 77	Cap Not Removed From C-14	b	One C-14
H77-51/H-126	29 Aug 77	Impact Damage	c	One DFS
H77-60/H-123	12 Oct 77	Aerial Retrieval Failure	e	Two DFS + C-14
H78-61/H-141	18 Nov 78	Balloon Sank Below Minimum Altitude	a	Two DFS + C-14

REASON FOR FAILURE (Mode)		NO. SAMPLES LOST
a) Balloon Failure		6
b) Human Error		7
a) Mechanical	1	
b) Electrical	6	
c) Impact Damage		5
d) Mechanical, Ground Support Equipment		3
e) Aerial Retrieval System		10
f) Mechanical, Flight Support Equipment		5
TOTAL		36

3.4 A summary of flights flown and samples collected by CY is:

1976

	TOTAL	SUCCESS	FAILED	% SUCCESS
Flights	10	5	5	50
DFS	14	6	8	43
AE	4	2	2	50
C-14	4	3	1	75

1977

	TOTAL	SUCCESS	FAILED	% SUCCESS
Flights	35	24	11	69
DFS	50	35	15	70
AE	10	8	2	80
C-14	19	15	4	79
Bellows	1	1	0	100
Aurora Measurements (P7670)	1	1	0	100
Whole Air Grab Sample (P6687)	1	1	0	100
Whole Air Grab Sample Schmeltekopf	10	10	0	100

1978

	TOTAL	SUCCESS	FAILED	% SUCCESS
Flights	26	25	1	96
DFS	24	22	2	92
AE	1	1	0	100
C-14	15	15	0	100
HV3K	4	4	0	100
Bellows	1	1	0	100
Cryogenic Sample	2	2	0	100
P6687	2	2	0	100
Cassette	3	3	0	100
Chlorine	1	1	0	100

3.5 In early 1977, parallel to the reconditioning of the SCADS-1A equipment, PSL performed a technical review of the SCADS-2 system and submitted a cost proposal for fabrication of three units. The proposal was funded and fabrication of unit 10 began in the second quarter of CY77. It was completed in Jul 77 and successfully flight tested on 29 Aug 77. On this particular flight, even though a hard impact occurred in unfavorable terrain, the unit survived these severe impact forces.

3.5.1 Following the successful test of unit 10, fabrication of units 11 and 12 began in the last quarter of CY77. These units were completed by mid-year 78 and were flown operationally in Jul 78.

3.5.2 Later that year, on 12 Oct 78, SCADS-2 unit 10 was destroyed in a hard impact, which occurred because of a failure of the aerial recovery system.

3.5.3 After this unit was lost, a replacement, unit 13, was assembled using existing spare components along with whatever new hardware was required. It was flown successfully in Nov 78.

3.5.4 Units 11, 12, and 13 are now flown operationally on the Ash Can balloon flights.

3.6 In November 1977 PSL began work on the design and fabrication of a pneumatic release device, which would facilitate releasing the payload from the launch vehicle and provide a safer environment for the man activating the release mechanism. The design and fabrication of a test model are complete; however, the testing was not accomplished by the end of the contract period.

3.7 In order to update the sampling system and make it compatible with SCADS-2, all PR-3 flow sensors were fitted with a more accurate, lower resistance thermistor, UUB31J1. All the PR -3 recorders were modified with a compatible resistance to accept this data from this thermistor.

3.8 As the quality of calibration of the PR-3 flow sensors improved, it became evident that more and more sensors would not calibrate within the 3%

acceptance criteria. This problem was traced to bearing wear. These units have been used for a number of years without the bearing being replaced or lubricated. Although these bearings are lubricated and sealed, wear and subtimation have reduced the amount of lubricant to a point where drag has become a significant factor. Once the problem was identified, new bearings were procured and replacement of the worn bearings begun. However, because of a long procurement time for these bearings, this effort was not complete by the end of the contract period.

3.9 A new silent diffuser was designed and fabricated in Jan 1978. After testing, five production models are now in use. This diffuser removes an environmental noise hazard that was present with the older model. It was named "The Polaris Silent Diffuser" after its designer, Elger Polaris Stauber.

3.10 In anticipation of a higher use rate of the Air Ejector System and a high concern for safety, PSL began a study of the titanium spheres used on this sampler. It has been proposed and accepted that these spheres be Kevlar wrapped, which would prevent fragmentation if a burst occurred. It would also allow higher man rated pressures and thus, longer sampling periods. Sources to do this work have been identified. However, because of a delay in funding, this effort was not accomplished by the end of the contract period.

3.11 In addition to the routine sampling operations, several flights requiring specialized payload buildups and integration; operational control or logistic support were flown successfully during the contract period. These flights were:

3.11.1 Flights H78-19/H-132X, H78-33/H-137X and H78-57/H-139X were cassette flights, which required a continous controlled valve descent from 120 Kft. to 60 Kft.

3.11.2 Closely akin to the cassette flights were the P6687/Cryrogenic Whole Air Sampling flights, which required varying descent rates at various sampling altitudes.

3.11.3 The most complicated of the flights, H79-53/H-138X, was a Chlorine measurements flight. This system employed a reel down device. A 1440 lb. load was reeled down 500 feet below the main loadbar. Dual command control units were required; one on the reel down payload and one on the loadbar. Close air coordination was required with a chase helicopter to land the experimenter at the impact site as soon as touchdown occurred.

3.11.4 Flight H78-41/A-146X was flown from Eielson AFB, AK during Sep 78. While in Alaska with another project, the requirement arose to conduct sampling using a HV3K sampler. Although this flight was not planned in the series, a crew was returned to Holloman AFB, the sampler readied and returned to Alaska, and the system was flown successfully.

3.11.5 Flights H77-47/H-118X and H78-04/127X were Metal Bellows flights, which required mating this sampler with a C-14 sampler. Sampling for both units was conducted during a controlled valve descent.

3.11.6 Flight H77-37 was an experiment flown from Eielson AFB, AK to make measurements of the Aurora. This flight required mating a contractor payload with modified Range Rack II instrumentation.

3.11.7 Finally, flight H76-65 was a tethered balloon test to provide an interference check.

4.0 SUMMARY OF THE WORK PERFORMED

- Conducted 71 balloon flights which included:

  Calibration of Equipment
  Assembling Payloads
  Rigging Parachutes
  Conducting Flight Operations
  Monitoring recovery activities
  Coordinating between using and control agencies
  Collecting data
  Reducing data
  Flight reporting

- Provided technical assistance for two balloon flights
- Fabricated and tested four SCADS-2 units
- Designed and tested a pneumatic release device
- Installed new thermistors in all PR-3 flow sensors
- Modified all PR-3 recorders to accept data from the UUB31J1 thermistor
- Identified cause of the PR-3 flow sensor calibration problem and procured new bearing to correct it
- Designed and produced a silent diffuser
- Deployed the flight operations to Panama and Alaska which required:

  Setting up command and control stations
  Setting up data acquisition stations
  Controlling balloon flights from a field station
  Planning and controlling the logistics and material
  to make these sites functional

5.0 No equipment was acquired during the contract period.

6.0 The balance of funds remaining after completion of this report is $1,787.44.